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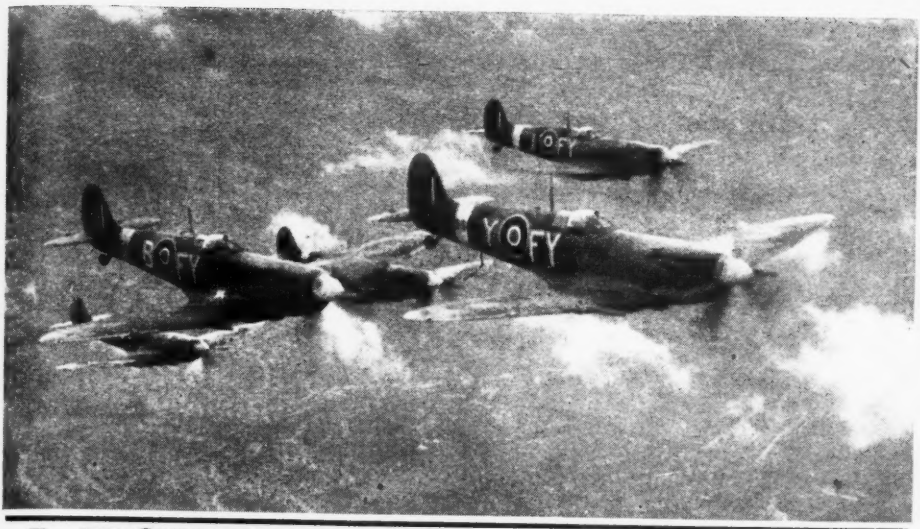

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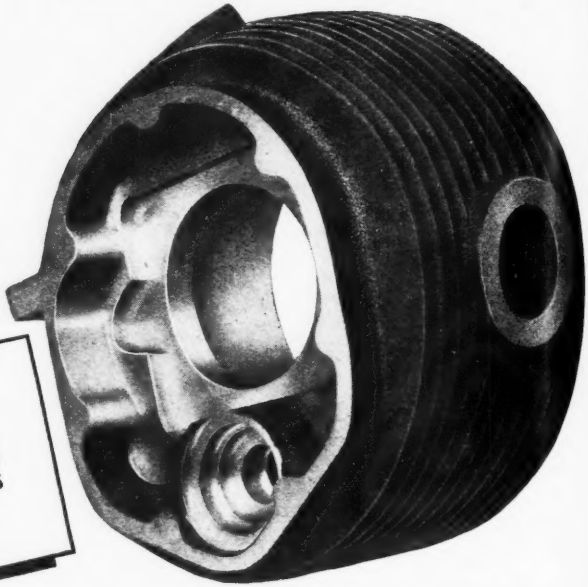

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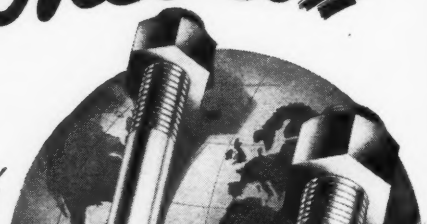

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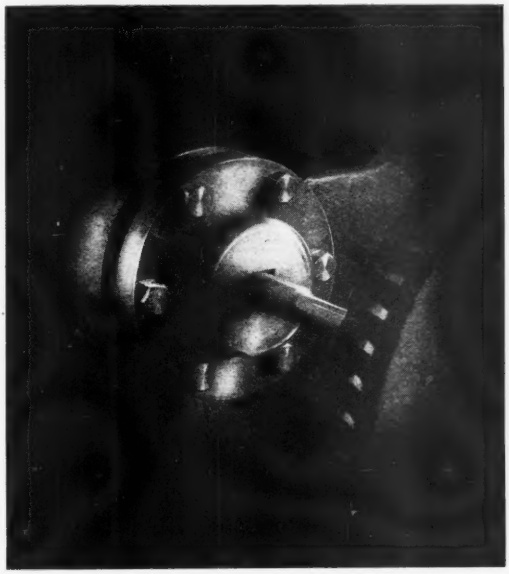

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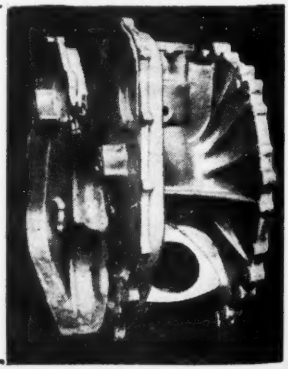

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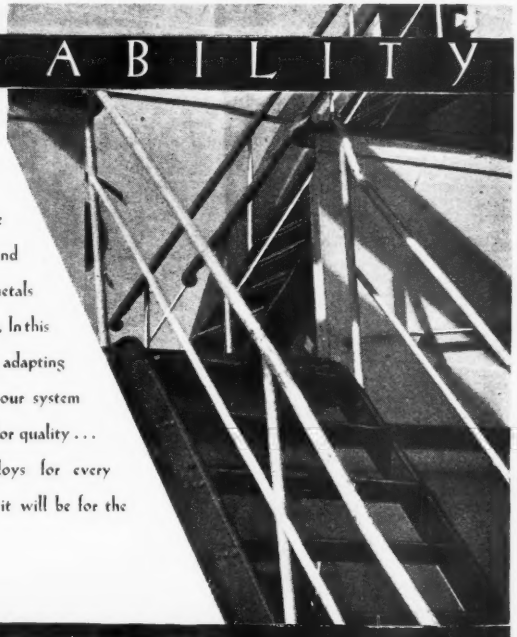

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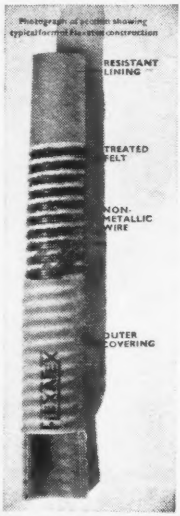

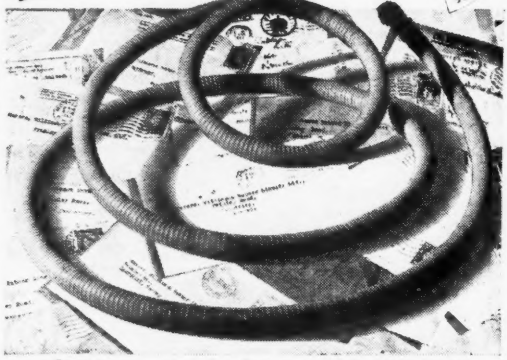

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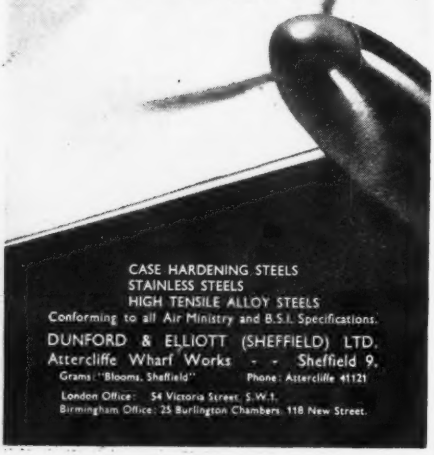

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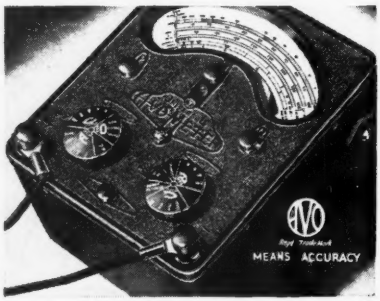

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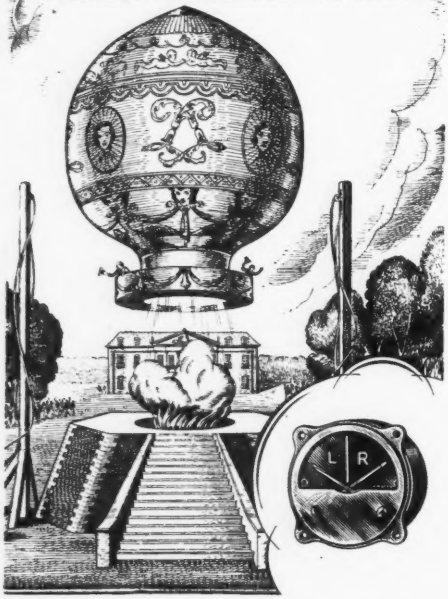

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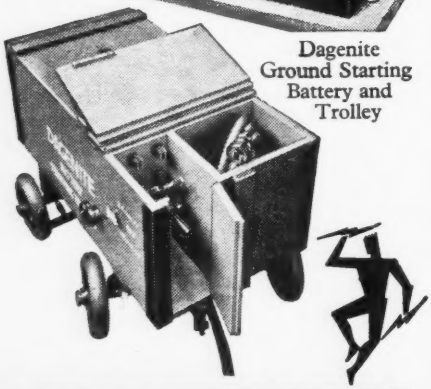

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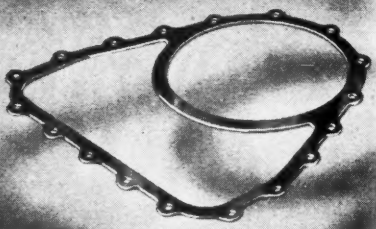

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Analytical Geometry in Layouts, I. S. J. Garvey and K. W. Hetz.
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MONTHLY NOTICES
MAY, 1943.

Wilbur Wright Memorial Lecture.

The 31st Wilbur Wright Memorial Lecture will be read on Thursday, May 27th, 1943, at 6.30 p.m., by Dr. E. P. Warner, F.R.Ae.S., on "Performance and Economy in Transport Aircraft." The Lecture will be held at the Institution of Mechanical Engineers, Storey's Gate, St. James's, S.W.1 (by kind permission of the Council of the Institution). Light refreshments will be served before the meeting.

Associate Fellowship Examinations.

It has been found necessary to hold the Associate Fellowship Examinations on three days instead of the usual two days. Candidates have been informed that the examinations will be held on May 18th, 19th and 20th, and full particulars sent to them.

Advertisements.

The fact that goods made of raw materials in short supply owing to war conditions, are advertised in the Journal, should not be taken as an indication that they are necessarily available for export.

Graduates' and Students' Section.

The following lectures have been arranged as Joint Meetings with the Graduates' Section of the Institution of Automobile Engineers, and will be held in the Library of the Royal Aeronautical Society, 4, Hamilton Place, W.1:—

Tuesday, 11th May, at 7.0 p.m.—Informal talk on "Plastics," by Mr. H. D. Curwen, the Editor of "Plastics."

Wednesday, 16th June, at 7.30 p.m.—"Applications of Photography to Engineering," by Dr. Baines, F.I.C., F.R.P.S., of Kodak Research Laboratory.

Wednesday, 14th July, at 7.30 p.m.—"Surface Finishing," by J. A. Oates, of "Aircraft Production."

Income Tax.

In response to numerous inquiries with regard to a rebate on Income Tax for their subscriptions, the following is a copy of a letter received from the Principal Inspector of Taxes:—

"Ref. H.R.S. 34/C.I. 4420/63.

Dear Sir,—Further to your interview with Mr. Stonely at this office on the 19th July, I am now in a position to inform you that the Board of Inland Revenue will not raise objection to the allowance as an expense for Income Tax purposes of annual subscriptions paid by members who are:—

(i) Assessable under Schedule D of the Income Tax Acts in respect of professional or trading profits, subject to the decision of the Commissioners who make the assessment that such subscriptions are sufficiently closely related to the business carried on; or

(ii) Assessable under Schedule E in those cases only in which continual membership of the Society is an essential condition of the terms of appointment.

Yours faithfully,

(Signed) GEO. WILCOCK,

Principal Inspector of Taxes."

Election of Members.

Associate Fellows.—James Arthur Beardsall (from Graduate), Donald Cameron-Douglas (from Associate), Alfred Maurice ffoulkes (from Student), Neville Austin Townsend, William Wilson.

Associates.—John Lawrence Batchelor, George Blachford, Albert William Dingle, Douglas Cole Greenwood (from Student), John Gregson, Lionel Albert Groom, Geoffrey Heaton, Eric Fred Hill, Robert George Swan Hogarth (from Student), Allan Gordon Honeyman, John Alexander Maurer (from Companion), Frank Leslie Prout, Maurice Shaw, Paul Siddens, Douglas Carl Stewart (from Student), John Lewis Stratford, Donald Launcelot Turner (from Student).

Graduates.—Augustine Kennedy (from Student), Abraham Robinson, Derek Victor Wordsworth.

Students.—R. R. Brooks, Peter Frederic Crawley, Frederick Russell Daniels, James Alexander Gwilym Diack, Peter William Dryland, Douglas Haig Duckworth, H. E. Farintosh, Leslie Edward Ellisson, George Herbert Higgins, Stanley Reginald Thomas Knibbs, Leslie Maidment, Walter Stewart Misener, John Lewis Mitchell, Marshall Morrison, John New.

Companions.—Frank Bernard Baker, Edwin Charles Comber, Andrew Adamson Jackson, Robert Arthur Saville-Sneath, Harold Vesey Strong.

Additions to the Library.

Pamphlets in italics with location reference following in brackets.
Books marked * or ** may not be taken out on loan.

A.a.296.—Fundamentals of Flight. R. Abbott. J. M. Dent and Sons 1942. 2/3.

A.c.14.—A Text-Book of Thermodynamics. F. E. Hoare. Edward Arnold. 1938. 15/-.

B.a.276.—Achievement in British Aircraft. S. E. Veale. Pilot Press, Ltd. 1943. 2/6.

B.a.277.—The Gen. Book. Charles Gardner. Hutchinson and Co. 1942. 7/6.

*B.a.278 and 279.—*Burney Hydrovane Seaplane Experiments*, 1911-1913. *Air Com. G. B. Dacre. Trials of D.A. Boat at Isle of Grain* (1921) *with Hydrovane Attachments. Air Com. G. B. Dacre. (Typescript.)* 1943. (Y.3.i.B. and Y.3.ii.D.)

B.a.290.—The World's Aeroplanes and Airships. G. Gibbard Jackson. Sampson, Low and Marston. (Abt. 1930.)

*B.g.125.—The Aircraft Calendar. Eric Sargent. Sampson, Low and Marston. 1938.

**B.g.126.—*Official Poster: German and British Aircraft. H.M.S.O.* 1915.

BB.c.85, 86.—*Screw Propeller Theory. J. Lockwood Taylor. E. and F. N. Spon, Ltd.* 1942. (*Reprint of paper read before N.E. Coast Instn. of Engineers and Shipbuilders, Feb. 6th*, 1942.) *Two copies.* (PBB.2.b.10 and 11.)

BB.c.87.—*Propeller Blade Vibration. J. Lockwood Taylor.* (*Preprint of paper to be read before Institn. of Naval Architects, May*, 1943.) (Y.1.b.13.)

C.c.61.—Ballooning. "Dromedary." Burlington Publishing Co. 1919.

*D.a.G.19.—*Statistics of Civil Aviation, Canada. Oct. and Nov.*, 1942. *Dominion Bureau of Statistics.* 1943. (File case.)

D.b.183.—Britain and World Air Transport. B. J. Hurren. John Crowther Publications. 1943. 2/6.

D.c.90, 91.—*Aerodromes* (*Analysis of Loadings*). *F. A. Phillips.* (*Reprint from "Constructional Review," Australia*, 1942.) (Y.4.ii.a.30 and 31.) Two copies.

D.d.17.—*Airwomen's Work. Leonard Taylor. Sir Isaac Pitman and Sons.* 1943. 1/6. (PE.2.b.10.)

E.d.16.—*Workshop Practice Simplified. P. W. Blandford. Sir Isaac Pitman and Sons.* 1943. 1/3. (PE.2.a.5.)

E.f.96.—*The Duties of a Licensed Aircraft Engineer. Air Registration Board.* 1943. 1/-. (PE.2.b.9.)

EE.c.68.—The Testing of High Speed Internal Combustion Engines. A. W. Judge. Chapman and Hall. (3rd Ed.) 1943. 42/-.

G.e.A.86.—*Heat Treatment of the Wrought Aluminium Alloys. Part I: Practice.* (*Bulletin No. 3 of Wrought Light Alloys Development Assn.*) 1943. (PG.3.a.16.)

G.e.K.9.—*Why Does Glue Stick?* (*Reprint from "Wood," March*, 1940.) *Aero Research, Ltd.* (Y.13.a.15.)

H.b.86.—*The Airman's Guide to his Rights and Duties. John L. Williams. The Haldane Society.* 1942. 1/-. (PH.1.b.6.)

I.d.7.—An Introduction to the Theory of Elasticity, for Engineers and Physicists. R. V. Southwell. (2nd Ed.) Oxford University Press. 1941. 30/-.

L.d.90.—Astronomical Air Navigation. Sq. Ldr. R. Hadingham. Technical Press, Ltd. 1943. 10/6.

R.f.86.—The Unending Conquest. (An Anthology of Flight.) R. de la Bère. J. M. Dent and Sons. 1938.

S.a.129.—In the Royal Naval Air Service. Harold Rosher. Chatto and Windus. 1917.

S.a.130.—German War Birds. "Vigilant." John Hamilton. 1933.

**S.a.131.—Souvenir of Australian and Malayan Battle Planes. (1914-1918.) C. Alma Baker. Privately printed (The Field Press). 1920.

**S.a.132.—History of the 17th Aero Squadron. (U.S.A.) F. M. Clapp. Privately printed. 1918.

S.b.124.—Wings of Destiny. Marquess of Londonderry. Macmillan and Co. 1943. 12/6.

S.b.125.—Wings on Her Shoulders. Katharine B. Beauman. Hutchinson and Co. 1943. 8/6.

S.d.83.—The Coming Battle of Germany. William B. Ziff. Hamish Hamilton. 1942. 7/6.

S.e.58.—The Fleet Air Arm. John Moore. Chapman and Hall. 1943. 5/-.

S.e.59.—R.A.F. in Russia. Hubert Griffith. Hammond, Hammond and Co. 1942. 5/-.

S.e.60.—Combat Report. Hector Bolitho. B. T. Batsford, Ltd. 1943. 8/6.

S.e.61.—The Flying Guns. Lt. C. E. Dickinson. Chas. Scribners' Sons. 1943. 10/6.

S.e.62.—One of Our Pilots is Safe. Flt./Lt. W. Simpson. Hamish Hamilton. 1943. 7/6.

S.e.63.—Bomber Pilot. Sqd. Ldr. L. Cheshire. Hutchinson and Co. 1943. 6/-.

T.b.—The Trail of the Conquerors. Col. P. T. Etherton and Vernon Barlow. Jarrolds, Ltd. 1936. 16/-.

T.b.83.—The Airway to See Europe. Eleanor Elsner. Albert E. Marriott. 1930.

*V.2/15.—Transactions of the Chartered Institute of Patent Agents. Vol. LX. 1941-1942.

In addition to the above we have also received a most interesting collection of pamphlets, photographs and other data, mainly relating to the Great War Period, presented by Col. F. A. G. Noel, as under:—

B.a.282-289.—Handbooks and pamphlets describing Aeroplane types. (1917-1920.)

EE.a.105-116.—Engine Handbooks. (1916-1920 types.)

M.b.48 and 49.—Pamphlets on Wireless and Signalling. (1915-1916.)

M.c.62-63.—Marconi Aircraft Wireless Installations. (Abt. 1920.)

S.b.120-124.—Organization of R.F.C. and R.A.F. (Regulations, etc., 1915-1920.)

J. Laurence Pritchard, *Secretary and Editor.*

STRESSING OF AIRCRAFT WHEELS AND BRAKES.*

H. Burkhardt.

Luftwissen, Vol. 8, No. 7, September, 1941.

Translated by L. J. Baker.

In modern aircraft, the flying performance, design of the airframe, engines, armament, or the military purpose are the features of principal interest, while the efficiency of the undercarriage is usually known only to a limited number of specialists. Shock-absorber legs, wheels and brakes are now such highly developed structural components that they deserve special attention. In the following, modern types of wheels and brakes are described in detail and the theoretical basis for the calculation of the landing process discussed.

Requirements to be Fulfilled by Aircraft Wheels and Brakes.

The following essential requirements must be fulfilled by aircraft wheels and brakes. The weight must be as low as possible. The external dimensions must be extremely limited taking into account the surface of equivalent drag and the operation of retracting the undercarriage in flight. In the case of an undercarriage retracting into the wings, for instance, the thickness of the wing and, consequently, the speed of flight will depend on the space required for the undercarriage. There must be a sufficient margin of safety for the case of forced landing. The required spring travel and work done in shock absorption must be shared between the wheel proper (tyre) and the shock absorber leg.

When taking-off, the bearing friction must be small, with gradual acceleration from rest to unsticking velocity and the possibility of overload. The undercarriage must be able to absorb the maximum load on the wheels of the fully loaded aircraft, including fuel, and the taxi-ing shocks.

Finally, when landing, the undercarriage must absorb the landing shock with sudden angular acceleration of the wheels from zero to the speed corresponding to the landing velocity. The run-out must be shortened by means of wheel brakes. In this way, usually about 50 per cent. of the energy of the landing aircraft is converted into thermal energy and absorbed in the body of the wheel. It should be possible to control the braking power for each side of the undercarriage separately and with opportunity for continuous adjustment (taxi-ing curves).

A number of requirements must be fulfilled to enable easy and thorough servicing of the undercarriage. Wheels and brakes must be easily interchangeable and robust in construction.

Tyre replacement should be easily effected with simple tools, and the wheel bearing should be self-contained and internally lubricated.

Thus, the design of the undercarriage should be governed by definite principles and every endeavour made to use easily obtainable material, at the same time taking into account all manufacturing possibilities. Extensive standardisation enabling the same type of wheel to be used on several aircraft types, is at the present time a normal requirement.

Of all the above conditions the requisite braking power is of particular importance in the design of landing wheels; accordingly braking requirements will now be specially discussed.

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Braking Energy and Necessary Braking Moments.

Denoting :—

E = energy of the aircraft at landing.
m = aircraft mass.
v_L = landing speed.
r = rolling radius of wheel.
s = braking distance.
M = braking moment of one undercarriage wheel.
P_R = static wheel load.

The energy of landing of an aircraft is calculated by the equation

$$E = \tfrac{1}{2} m v^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Experience shows that in a normal landing about 50 per cent. of this energy is absorbed by rolling friction, induced air drag due to ground effect, etc., so that the brakes are required absorb :—

$$E_{Br} = \tfrac{1}{4} m v^2$$

$$\text{or} \qquad Q_{Br} = \frac{m v^2}{4 \times 427} \text{ (kcal)}$$

With a landing weight of 9,000 kg. and landing speed of 150 km./hr., we obtain, for instance, a braking power of

$$Q_{Br} = \frac{9000 \times 41.66^2}{9.81 \times 2 \times 2 \times 427} = 940 \text{ (kcal)}$$

Thus, each wheel has to absorb 470 kcal. For the case of a forced landing (failure of the landing aids), we will assume that the landing speed is increased by 20 per cent., *i.e.*, to 180 km./h. The braking energy is then increased to

$$Q_{Br} = \frac{9000 \times 50^2}{9 \times 81 \times 2 \times 2 \times 427} = 1320 \text{ (kcal) or } 660 \text{ (kcal) per wheel}$$

and is, therefore, already greater by 40 per cent. If it is borne in mind that the braking process is completed in 15 to 20 secs., at the most, it is obvious that it will not be quite a simple matter to dissipate these quantities of thermal energy in the body of the wheel. This problem can be solved by using double brakes, *i.e.*, separate brakes on each side of the wheel, and special heat absorbing devices. The table compares the heat loads on motor lorry and racing car brakes with those on landing wheel brakes.

Assuming that a braked aircraft landing is required to be completed in a taxi-ing length of $s = 300$ m., the required mean braking moment can be calculated empirically by the equation

$$M = E_{Br} r / s \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

In this example, if the radius of rolling $r = 0.45$ m., we have :—

$$M = \frac{200{,}000 \times 0.45}{300} = 300 \quad . \quad . \quad . \quad . \quad (7)$$

At the same time care must be taken that the friction between tyre and ground, remains within permissible limits. In the present case, if about 10 per cent. is deducted for the tail load, the wheel load can be taken as $P_R = 4{,}100$ kgs.

The coefficient of ground friction will then be

$$\mu = \frac{M}{P_R \times r}, \text{ hence}$$

$$\mu = \frac{300}{4100 \times 0.45} = 0.16$$

We know from experience that in the case of friction between rubber and grass, values up to 0.25 are obtained for μ, and in the case of rubber on concrete values up to 0.5. Thus, when landing on concrete much higher braking moments

can be used provided they are not limited by the wear on the tyres and the equilibrium of the aircraft. A concrete landing path allows of shorter landing runs and thus requires higher braking power.

Design of Brakes.

Modern German aircraft are principally equipped with pressure-oil operated internal drum wheel brakes with dual servo control. The action of the duo-servo brake is explained in Fig. 1. The first brake block is applied by the operating device K (oil pressure cylinder). The resultant normal force N_1 and the frictional force μN_1 produce a bearing force at the joint A_1 which acts simultaneously with the force operating the block 2. The servo motor action of the first brake block again produces a greatly increased servo motor action on the second brake block. Thus, with relatively small forces K, very considerable braking moments are obtained, although a separate brake is then required for each direction of running. The development of the braking moment of a brake is very regular without peaks or variations over the whole length. The brake drum and the brake blocks are suitably made of cast electron which has proved most reliable. The brake linings are made of German material free from asbestos.

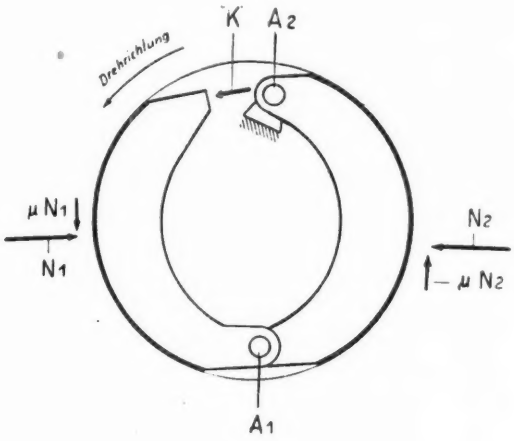

Fig. 1.

Internal-drum duo-servo landing-wheel brake of cast electron. Drehrichtung=direction of running.

Wheel Design.

All the conditions required in a modern landing wheel are fulfilled in a great measure in the double-brake landing wheel, made of cast electron and has two duo-servo oil pressure brakes, and shown in a cross-section in Fig. 2.

Low weight is secured by the use of magnesium alloys and effecting heat absorption in the body of metal already required for reasons of strength.

Approximately 0.012 kg. wheel weight including two brakes but excluding tyres, are required for each 1 kg. load-carrying capacity. Since the brakes are accommodated within the limits of the outer wheel rims, the tyre profile is not exceeded. Wheels and brakes are capable of carrying overloads; safety in emergencies is ensured by suitable tests. Substantial ball-bearings ensure low bearing friction. Resistance to fracture in the wheel body is remarkably high owing to the compact construction and the supporting effect of the brake drums. The breaking load is about eight times the maximum static wheel load. Reasons

of economy, however, prevent a possible reduction in the cross-sections for reducing weight. The brake energy is well under control, being partially accumulated during landing and then radiated to the surrounding air.

The wheel and brakes form a unit, integrally fitted on the axle, ready for service as soon as the brake-pipes have been coupled and the working fluid filled. It should be noted that the brake lining must of course be kept absolutely free from grease and oil. It should also be noted that erroneous statements are frequently made about the appearance of the brake lining in the working condition. It should be definitely stated that a properly run-in brake with, *e.g.*, Buna-steel linings, has a glass-smooth surface. The more polished the surface (carefully avoiding any oil or grease), the better the braking action. It can never be improved by roughening the surface of the lining, quite the contrary, it deteriorates. The ideal condition is a finely polished brake drum and a highly polished brake lining free from any grit or dirt.

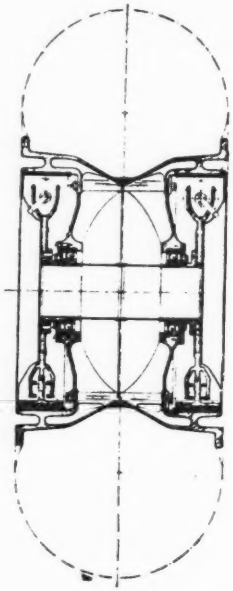

FIG. 2.

Cross-section of aircraft wheel with two duo-servo and pressure brakes.

Special covering plates protect the brakes from external dirt. The wheel body can be separated into two parts by releasing the rim-screws, so that the tyres are easily fitted. There is no need to release the enclosed split bearing for this operation. The ball-bearings are packed with grease when the wheel is first assembled and there is no further need for lubrication during the whole period of operation because complete tightness is assured by packing rings of Buna.

As the magnesium casting alloy used is a domestic product it can be produced on a large scale. It is interesting to note that owing to their special construction, it has been possible to make the brake drums of straight cast iron which hitherto appeared impossible on account of the braking power required in the present case. Needless to say, the components and the entire wheel are interchangeable.

Landing-wheel manufacturers have succeeded in fulfilling all the requirements for this type of wheel, using exclusively domestic material. Thus wheels and brakes make an important contribution to the general excellence of German aircraft.

TABLE.

	Total weight. kg.	Range of braked speed. km./hr.	Brake energy on each wheel. m./kg.	Heat load per wheel. K/cal.
(4 wheels, 4 brakes)				
High speed motor lorry	5000	80 to 0	31,000*	73
Racing car (4 wheels, 4 brakes)	1000	250—100 (before curves)	52,000*	120
High speed aircraft (2 wheels, 4 brakes) ...	9000	150—0 (180—0)	200,000 (280,000)	470 (660)

* Actually even less, since the air and rolling resistance are not taken into account.

PLASTICS AND THEIR APPLICATION TO AIRCRAFT CONSTRUCTION.*

J. T. Zhibitsky.

Aviation Industry, U.S.S.R., No. 4, Jan., 1941.

Translated by V. Akimoff.

Economical organisation and practically inexhaustible supplies of raw material in our country create exceptionally favourable conditions for the rapid development of the plastics industry. The raw material is drawn from the by-products of various branches of the chemical and agricultural industries.

By their technical properties, plastics present many advantages over many other materials. Some of them are as strong as metal, as transparent as glass, and as light as wood. Plastics are endowed with high dielectric properties, great thermo-stability, and low conductibility for sound and heat; they can be machined, pressed, moulded, and have a pleasing exterior.

For aircraft construction, plastics are especially valuable because of their high mechanical properties with a low specific gravity (1.4 on the average), their resistance to corrosion and their capacity to absorb vibrations (all this makes them of practically unlimited fatigue strength).

Most plastics are highly resistant to sea water. They can, therefore, be used in the construction of sea-planes, since duralumin gets corroded by sea water, and wood, even when varnished becomes warped and swells in it.

Types of Plastics and Their Application.

The constructional plastics—"textolit" and "getinax"—are laminated. They can be prepared by impregnating sheets of fabric (textolit) or of paper (getinax) with resin and, after drying, pressing them between steel plates at 120° to 150°C., and 70-120 kg./cm.^{2} pressure. Both materials possess the valuable property of damping torsional vibrations. In this respect, they are superior to many other materials, including wood. The specific heat of textolit is three times that of metal, and its heat conductivity 1/60 to 1/40, it can, therefore, be used as a heat insulating medium.

The electrical characteristics of laminated plastics vary considerably with the quality of the raw materials, temperature, method of production, etc. Thin sheet getinax is used for making the different instrument boards in aircraft. Where there is a possibility of the properties of the dielectric being affected by moisture, the instrument boards should be made of textolit. Better qualities of both textolit and getinax have been experimentally manufactured. Some types of textolit, for instance, have been obtained, with a tensile strength up to 18 kg./mm.^{2}, a value of Young's modulus up to 1,700 kg./mm.^{2}, and a fatigue limit in alternating bending up to 10 kg./mm.^{2}.

The low conductivity of textolit for heat prevents it from being used widely for high speed shaft bearings; for the same reason, it can be used as anti-friction material only in units working with water lubrication and under high specific pressure (up to 150 kg./cm.^{2}) but at low speeds.

Graphite-loaded textolit, on the other hand, may be used for high speed bearings working under low specific pressures (up to 10 kg./cm.^{2}). At low speeds

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and with water lubrication, it is preferable to use textolite instead of bronze bearings.

The low shrinkage and the low frictional coefficient (1.0-0.38) of textolit on steel has contributed to its being employed instead of bronze in the bearing of rolling mills. At the Iwanovsky Textile Machinery Works an attempt is being made to replace non-ferrous metals by textolit, using a process developed and generally practised by the Works, in which a thin layer (1.5 to 3 mm. thick) of the plastic is applied to the surface of steel parts which are heat treated afterwards; such steel parts can successfully replace brass parts.

In addition to textolit and getinax, film-bonded plywood is also used in aircraft construction; this plywood differs from the ordinary in that the veneers are bonded with a film of phenol-formaldehyde resin and thin paper instead of albumin glue. The film-bonded plywood is employed to make the skin of the aircraft wings and fuselage, the bottom planking of flying-boat and seaplane hulls, and also of the body of gliders. This plywood is highly resistant to prolonged exposure to water or damp air, especially if protected with a coating of enamel paint.

Plastics on a phenolic resin basis without a filler have a short time tensile strengths of 3.6 to 4.3 kg. mm.^{2}, and a short time compression strength of 15 to 17 kg./mm.^{2}. The mechanical properties of such plastics are considerably improved by the addition of a filler.

Plastics made of a phenolic resin and a flax corded fabric have a short time tensile strength of 50 kg./mm.^{2}, a compression strength of 21.7 kg./mm.^{2}, and a shear strength of 1.4 kg./mm.^{2}, with sp.g. 1.45. From the standpoint of its shear strength, this material does not meet the requirements of aircraft construction. A phenol resin plastic with cellulose filler, prepared at 150°C. and 320 atm. pressure (short time tensile strength 14.4 kg./mm.^{2}, compression strength 15.5 kg./mm.^{2}, shear strength 5 kg./mm.^{2}, and sp.g. 1.39) was used in England in the construction of an experimental wing section.

In aircraft and engine construction, as is known, considerable importance attaches to paired materials, possessing a high and a low coefficient of friction, respectively. The best among such friction pairs is an asbestos filled plastic and steel.

Plastics are particularly characterised by their high resistance to wear. They have a high coefficient of friction when working without lubrication, but a very low one when lubricated with oil or water. Owing to their good frictional properties, they are advantageously used for brake bands and blocks, bearings, pump pistons and rubbing parts, etc.

Three main types of plastic bearings materials are in use to-day. The first type is made of fibrous asbestos with an admixture of kaolin and phenol resin (" asbolit "). The compressed material can be used for brake linings. The second type is a combination of an asbestos tape, a thin copper or brass mesh, and one of the phenol resins (ferodo tape). The third is a laminated plastic consisting of asbestos fabric and phenol resins (" asbotextolit "). Owing to its high mechanical properties, this material can be used for parts under load, *e.g.*, coupling discs, pump sleeves in aircraft engines, etc.

Brake bands on a phenol-formaldehyde basis can usually stand from 500 to 1,000 landings, and work with a uniform increase in braking moment in operation.

Insulation against heat and sound is of considerable importance in aircraft construction. The best sound-insulating material is felt, " viamiz " [sic] being the next best. But since the density of a " viamiz " is one-tenth of that of felt, it should be used by preference in aircraft construction. " Viamiz " is a special type of porous albumin [sic casein] plastics. It can be easily cut and easily moulded when hot; it can be bonded with wood and metal, is fire-resistant, and is not soluble in alcohol or petrol.

A large assortment of various joint packing materials are used in aircraft construction, *e.g.*, gaskets, cements, etc. These cements are made from synthetic resins, especially phenol-formaldehydes, which are resistant to the action of petrol, oils, and high temperatures.

Among transparent plastics, an important part in the aircraft industry is placed by polymerization products, especially the polacryls, from which organic glass is made (Plexiglass).

Plexiglass is frost-resisfant and colour-fast. It is used for aircraft windscreens and lamps, and also for unbreakable flying goggles. The polyacrylic resins are thermoplastic, and articles can be made of them by moulding or extrusion.

The group of polymerization resins includes, among others, also the plastic of German production—mipolam—remarkable for its high fire resistance, toughness and elasticity. There are many varieties of mipolam: Transparent like glass, opaque, colourless and coloured. All types of mipolam stand rapid heating up to 80°C. without noticeable decomposition, but if heated for a longer time, the temperature must not exceed 80°. The hard types of mipolam begin to soften at 60° to 70°, and become brittle when cooled down to −30°C. Powdered mipolam is easily moulded in steel at 130° to 135° and 300 kg./cm.^{2} pressure. The articles are removed from the moulds after cooling down to 50°. Solid mipolam is insoluble in alcohol, petrol, naphtha oils, castor oil, turpentine, but easily soluble in acetone, ether, benzol and hydrogen sulphide.

Windscreens, lamps, etc., can be made of transparent mipolam by stamping. In aircraft, the transparent plastics are exposed to the action of ultra-violet rays, atmospheric humidity, and temperature. Plastics, as a whole, differ in their resistance to these factors: Cellon and celluloid have the drawback of not being frost resistant, for which reason cellon is used chiefly for making triplex glass. Celluloid is discoloured in yellow by the ultra-violet rays, and is highly inflammable, this rendering its use in aircraft construction of secondary importance.

Working of Plastics.

Many various articles can be moulded from plastics, without further working. While presenting conspicuous advantages, this can be financially profitable only in mass production, where the price of the finished article is but little affected by the cost of the fairly expensive moulds.

High cutting speeds and a small thickness of the chips are required in machining brittle plastics. It is necessary to consider the different degree of strength of the plastics (especially textolit) in the planes parallel with and perpendicular to the fabric layers. Great experience and skill are therefore requisite for drilling and finishing off holes, and thread cutting in parts made of textolit.

In the process of moulding, the plastics on a phenol-aldehyde resin basis pass, as is known, from the initial stage A (" resol ") through the intermediate stage B (" resitol ") to the final stage C of condensation (" resit ").

The temperature of moulding (150° to 170°C.) of plastics fluctuates within the limits of ±30°. Owing to this fact, some lots of the finished articles contain more resin transformed into resit than other lots, whence the variability in the mechanical properties of the articles.

To avoid this defect, pheno-plastics of the textolit type are subjected to an after-treatment by heat (" normalisation ") in an air thermostat or in hot oil at 130°C. for 24 hours. The mechanical properties of textolit before and after normalisation (according to P. M. Kozlov's data*) are shown in Table 1.

* P. M. Kozlov. Plastics in aircraft construction. Moscow-Leningrad. Oborongiz, 1938.

TABLE I.

Temperature of sample at rupture.	Breaking strength, kg./mm.		Loss of strength, %.	
	Raw textolite.	Normalised.	Raw textolite.	Normalised.
	9.2	9.8	—	—
75	7.	8·1	24.0	18.0
100	6.1	7·7	34.0	20.5
150	.6	7·4	50.0	24.0

The data in this table indicate that textolit normalised at a temperature of up to 150°C. is twice as strong as the non-normalised.

Sheet textolit is liable to warp if pressure fluctuates during the moulding process. This defect may be remedied by annealing. This is done by alternating periods of rapid heating of the warped sheets up to 250°-260°C., and of a slow cooling down to normal temperature (while cooling, the sheet is placed on an edge). It is also advisable to anneal parts after rivet holes have been drilled in them.

The structure of the plastics should be borne in mind when subjecting them to heat treatment. The plastics are composed of complicated groups of atoms of carbon, hydrogen, oxygen, nitrogen, and other elements, and the strength of the bonds of these atoms is considerably weaker than in metals and metallic alloys. Therefore, the most resistant plastics must not be heated above 300° to 360°C., since at higher temperatures the plastics begin to carbonize.

APPLICATIONS OF PLASTICS ABROAD.

According to information from the foreign press, the use of plastics for aircraft construction is growing fast abroad.

" Aircraft Engineering " (March, 1939, p. 96) states that the range of the plastics employed in aircraft production, and those still in the experimental stage has been considerably extended. Thus, for instance, acetate-cellulose plastics are used in the form of sheets, bars, etc., for windscreens, steering-wheels, and other parts.

Phenol-formaldehyde resins are of the greatest importance in aircraft construction. Here again, much depends on the correct choice of the filler and of the impregnation method. The best filler for aviation purposes is fibrous materials. The journal also gives a comparative table of the mechanical properties of bakelites (pheno-plastics); *cf.* Table 2.

TABLE II.*

Material.	Short time tensile strength, in kg./cm.².	Weight of sample 30cm. in length, in kg.	Spectfic tensile strength (strength/wt.) in kg./cm.².	Young's modulus E – (10^6 units), in kg./cm.² : kg.	Specific stiffness – E/ wt. (10^6 units), in kg./cm.² : kg.
Spruce . . .	1,265	0.077	16,435	0.105	1.37
Improved wood .	2,461	0.226	10,888	0.281	1.24
Bakelite (F294 Fabric) . .	738	0.277	2,665	0.119	0.43
Bamboo. . .	2,812	0.222	12,668	0.316	1.42
Steel . . .	9,491	1.524	6,227	2.109	1.38
Duralumin . .	3,515	0.562	6,255	0.752	1.33
Elektron . .	2,376	0.354	6,712	0.422	0.19

* According to A. P. King's data in " Aircraft Eng.," March, 1939, p. 96.

As early as 1937, De-Bruyne, Director of the Aviation Research Laboratories in Duxford, pointed out that the problem of finding a plastic of equal mechanical

properties as wood or metal, had not yet been solved, but that some plastics were already existing, which could be used in aircraft construction. De-Bruyne's paper, published at the end of 1939,* contains a comparative table of the mechanical properties of certain plastics; for the sake of comparison, the mechanical properties of steel are given in Table 3.

TABLE III.

Material	Density γ.	Specific tensile strength σ Kg./cm.^{2}/γ.	Specific compression strength σ Kg./cm.^{2}/γ.	Specific shear strength τ Kg./cm.^{2}/γ.	Specific stiffness under tension E Kg/cm.^{2}/γ
Cord-material .	1.34	1,315	1,417	304	0.126×10^6
Gordon aerolite .	1.43	2,215	1,181	245	0.295×10^6
Duralumin . .	2.8	138	1,385	752	0.251×10^6
Spruce . . .	0.5	1,406	703	105	0.183×10^6
Steel . . .	7.8	1,624	1,624	949	0.271×10^6

The new plastic "Gordon aerolite," with flas for filler, is not inferior in its properties to any other of the principal materials used in aircraft construction. De-Bruyne stresses the importance of exposing the fibres (threads) correctly when impregnating the material. A special machine is used for this purpose; it produces a uniform band which is passed through a bath. After impregnation and drying, the material is compressed in a 800 tons hydraulic press, permitting the moulding of double T-shaped longerons of unlimited length. De-Bruyne considers that it should soon be possible to organise the production from plastics of whole aircraft wings and fuselages.

Another example of the application of plastics to aircraft construction in the U.S.A. is given by "British Plastics" (Vol. 10, No. 18, March, 1939, pp. 528-584), which states that airscrews in that country are made by the methods of the German firm Schwartz, and of the English concern "Airscrew Co." The blades of the airscrew are made of spruce plywood or of some other soft wood, and are set in a socket of hard wood. The socket is built up of veneers 3 mm. in thickness. Each veneer is impregnated with a phenol resin and is subjected to high pressure and temperature.

The socket of the blade is fixed in a steel sleeve secured in the hub of the airscrew. The blades are covered with a thick layer of reinforced cellulose acetate, and the leading edge is protected by a tightly fitting metal strip. Such blades are about 33 per cent. lighter than duralumin blades; they damp vibrations and are not subject to weather effects.

In the U.S.A., the aircraft Clarke 46 is now undergoing practical tests; its fuselage is made of duramould, which is a plastic on a phenol basis with a wood filler. Duramould differs from the usual type of plastics in that it does not require high pressures and temperatures in moulding. Like other plastics, duramould can be die-moulded.

The density of duramould varies from 0.5 to 0.9 according to the method of its preparation. Its strength and modulus of elasticity vary with its density. According to the data in "Luftwissen," the principal types of duramould are characterised by the following mechanical coefficients:—

With the load applied in the principal direction: Breaking strength 18.1 kg./mm.^{2}, compression strength 9.8 kg./mm.^{2}, Young's modulus 2,150 kg./mm.^{2}.

With the load normal to the principal direction: Breaking strength 3.32 kg./mm.^{2}, compression strepgth 5.42 kg./mm.^{2}, Young's modulus 500 kg./mm.^{2}; or, breaking strength 11.7 kg./mm.^{2}, compression strength 7.9 kg./mm.^{2}, Young's modulus 1,440 kg./mm.^{2}.

* N. A. De-Bruyne. "Flight," No. 12, 1939, Plastic Progress.

With the load normal to the principal direction: Breaking strength 9.75 kg./mm.^{2}, compression strength 7.3 kg./mm.^{2}, Young's modulus 1,215 kg./mm.^{2}.

Duramould is not hygroscopic; it is resistant to corrosion and atmospheric influences; its fatigue strength is considerably greater than that of duralumin; it is fireproof and possesses the property of absorbing the energy of vibration. The heat-insulating capacity of duramould is very high, and therefore it resists icing much better than metals.

The construction of aircraft from duramould requires much less time than that of all-metal machines. The surface of the moulded part is very smooth, this reducing air drag and increasing the speed of flight by about 7 per cent.

The absence of knots, joints, etc., renders the whole constructions, so to speak, monolithic; this diminishes the danger of any of the different important component parts being broken off in combat.

In our country, plastics have been so far used comparatively little in the construction of aircraft. They are chiefly employed for making the controls of the aircraft and engine, the navigational and electrical instruments, and the cockpit window frames. All this constitutes but a fraction of one per cent. of the whole aircraft mass, while the scope for the application of plastics in aircraft construction is very wide indeed.

The rapid development of the preparation and application of plastics in the Soviet aircraft industry is an urgent and imperative problem.

THE ROYAL AERONAUTICAL SOCIETY

WITH WHICH IS INCORPORATED THE INSTITUTION OF AERONAUTICAL ENGINEERS.

SEVENTY-EIGHTH ANNUAL REPORT OF THE COUNCIL, 1942-1943.

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Secretary and Editor:
Captain J. Laurence Pritchard, Hon. F.R.Ae.S., A.F.I.Ae.S.

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Professor L. Bairstow (Chairman), Mr. S. Camm, Captain P. D. Acland, Mr. Griffith Brewer and Mr. H. E. Wimperis.

REPRESENTATIVES ON OTHER BODIES.

The following were appointed as the Society's Representatives on other bodies:—

Advisory Committee for Aeronautical Engineering of the City and Guilds of London Institute: Professor F. T. Hill and Captain J. Laurence Pritchard.

Advisory Council of the Science Museum: Lord Sempill.

Air League of the British Empire: Mr. W. O. Manning and Mr. Griffith Brewer.

Association of Special Libraries and Information Bureaux: Mr. J. E. Hodgson (Honorary Librarian).

General Board of the National Physical Laboratory: Mr. Griffith Brewer and Mr. W. C. Devereux.

British Standards Institution, Aircraft Committee: Major R. H. Mayo and Dr. H. C. Watts.

British Standards Institution, Committee on Symbols and Abbreviations Used in Engineering: Dr. H. Roxbee Cox.

British Standards Institution Technical Committee on Aircraft Nomenclature: Professor L. Bairstow, Captain J. Laurence Pritchard.

British Standards Institution, Units and Technical Data Committee: Lieut.-Col. W. Lockwood Marsh.

Engineering Joint Council: Mr. A. Gouge.

Engineering Joint Council, Special Educational Representative: Professor G. T. R. Hill.

The Guild of Air Pilots and Air Navigators of the British Empire, Sefton Brancker Memorial Fund Committee: Captain P. D. Acland.

Joint Standing Committee with the Society of British Aircraft Constructors and the Royal Aero Club: Mr. E. F. Relf, Lord Sempill, Lord Brabazon, Air Vice-Marshal R. M. Hill, Mr. W. C. Devereux.

National Central Library: Mr. J. E. Hodgson (Honorary Librarian).

Professional Classes Aid Council: Lord Sempill.

Seagrave Memorial Fund Committee: Sir Richard Fairey.

Ministry of Labour, Engineering Advisory Committee: Sir Roy Fedden, Captain J. Laurence Pritchard.

Institution of Mechanical Engineers, National Certificates and Diplomas in Mechanical Engineering: Sir Roy Fedden and Professor F. T. Hill.

MEMBERSHIP.

The Membership of the Society for 1942, the third full year of the war, shows a net increase over 1941.

Following the outbreak of war there was a considerable increase in applications for membership of the Society. Many of these applications came from qualified engineers who had entered or been called into the industry and the Royal Air Force and most of them were rejected, as the Rules for Associate Fellowship call for five years aviation experience, and for Associateship for three years.

The Council feel, in view of the probable considerable expansion in civil aviation after the war, that it is more important than ever to safeguard the high standard of Associate Fellowship in order that its value will not be lessened.

The following table gives the present membership, exclusive of the Branches:—

MEMBERSHIP OF THE SOCIETY, DECEMBER, 1942.

	No. of Paid Members.	Honorary and Life Members.	Suspended Members.	Grand Totals.
Fellows	... 217 (215)	24 (23)	3 (4)	244 (242)
Associate Fellows	... 1134 (1060)	7 (6)	38 (66)	1179 (1132)
Associates ...	... 459 (346)	4 (3)	21 (28)	484 (377)
Graduates ..	... 214 (164)	— —	9 (7)	223 (171)
Companions ...	... 130 (107)	9 (10)	8 (13)	147 (130)
Founder Members	... 16 (17)	1 (1)	— (1)	17 (19)
Students	... 606 (557)	— —	47 (74)	655 (631)
Temporary Honorary Members ...	... — —	17 (17)	— —	17 (17)
Totals ...	... 2778 (2466)	62 (60)	126 (193)	2966 (2719)

NOTE. Figures in brackets give the membership as at December, 1941

DONATIONS.

The Council have to thank the Air Ministry for the eighteenth year in succession for their grant of £250 to the Funds of the Society, and the Society of British Aircraft Constructors for a similar grant over a similar period.

In the report of the Council for 1939-1940 a history was given of the initiation and progress of the Endowment Fund. Many generous gifts, spread over seven years, have been made, and the table below shows the progress of the Fund.

	£	s.	d.
December, 1926	575	0	0
December, 1927	597	2	0
December, 1928	1,047	18	0
December, 1929	1,077	6	0
December, 1930	1,265	10	0
December, 1931	1,939	10	0
December, 1932	2,196	2	0
December, 1933	9,716	19	5
December, 1934	10,131	14	11
December, 1935	10,895	10	7
December, 1936	11,138	16	7
December, 1937	11,474	3	7
December, 1938	12,211	12	11
December, 1939	51,048	14	6
December, 1940	64,740	17	9
December, 1941	78,616	14	4
December, 1942	93,353	4	3

SOCIETY'S HEADQUARTERS.

The Society has continued throughout the year to function from its Headquarters, No. 4, Hamilton Place. During the year the building has suffered no further damage from air raids.

ANNUAL GENERAL MEETINGS.

The following is an abbreviated report of the Annual General Meeting of the Society, held on Saturday, March 28th, 1942, in the Offices of the Society, No. 4, Hamilton Place, W.1.

Mr. Griffith Brewer (President) in the Chair.

Present: Miss A. Baden-Powell (Honorary Companion), Dr. A. B. Barbour (Companion), Mr. H. Barnes (Companion), Mr. V. J. Chalwin (Associate), Mr. J. E. Chorlton (Companion), Mr. C. R. Elgie (Associate), Professor F. T. Hill (Fellow), Mr. G. Ingram (Companion), Sir Francis McClean (Associate Fellow), Mr. Peter Masefield (Associate Fellow), Mr. L. Mawer (Associate Fellow), Mr. J. P. Pryer (Associate Fellow), Mr. W. Reichsfeld (Associate Fellow), Warrant Officer J. V. Saunders (Associate Fellow), Lieut.-Col. S. Heckstall-Smith (Fellow), Mr. H. Smith (Student), Mr. R. T. Wall (Student), Dr. H. C. Watts (Fellow), Mr. J. A. C. Williams (Graduate), Mr. Lawrence A. Wingfield (Associate), Mr. R. T. Youngman (Fellow), Mr. A. R. Pitt (Student).

In attendance: The Secretary and Miss Barwood.

1. The Secretary read the Notice convening the Meeting.

2. The President said a copy of the Annual Report was in the hands of all those present and he hoped they would make any comment they thought fit.

He would like to make a personal apology for his absence from the last Annual General Meeting, owing to his absence in America. There he had been invited, as President of the Society, to give the Address at the Honours Night Meeting at the Institute of the Aeronautical Sciences. While in America he had also

been able to arrange for Mr. Juan Trippe, the President of Pan-American Airways, to deliver the Wilbur Wright Memorial Lecture in London.

In the Annual Report he was glad to see that three Fellows of the Society, Professor Melvill Jones, Mr. Fedden and Mr. Fairey, had received the honour of Knighthood, and one, Lieut.-Col. J. T. C. Moore-Brabazon, had been elevated to the Peerage.

The Staff of the Society had been reduced to less than one third since the outbreak of war, and though there had been a temporary lull in activities for the first few months, the work of the Society had since been steadily increasing. This had thrown a considerable burden on the staff and he would like the meeting to pass a vote of thanks for the excellent work they were doing.

He would like to draw attention to the able way the Secretary, Captain Laurence Pritchard, had edited the Society's Journal during a very difficult period, and for his work on behalf of the Society which had been so steadily built up during his period of office. The responsibility on his shoulders during the war period was heavy and he thought the Society were fortunate that he was at the helm.

The vote of thanks was passed unanimously.

3. The Secretary reported that the following had been nominated to fill the vacancies on the Council and would serve for the years 1942-1944:—

Mr. R. Blackburn.
Dr. Roxbee Cox.
Mr. G. H. Dowty.
Mr. E. C. Gordon England.
Captain A. G. Lamplugh.
Mr. R. K. Pierson.
Dr. D. R. Pye.
Mr. E. F. Relf.
Mr. A. Hessell Tiltman.
Mr. C. C. Walker.

4. Messrs. Price, Waterhouse were re-appointed Auditors for the Society's Accounts for the ensuing year.

SPECIAL GENERAL MEETING.

A Special General Meeting of the Society was held immediately following the Annual General Meeting, on Saturday, March 28th, 1942, in the Offices of the Society, No. 4, Hamilton Place, W.1.

Mr. Griffith Brewer (President) in the Chair.

Present: Miss A. Baden-Powell (Honorary Companion), Dr. A. B. Barbour (Companion), Mr. H. Barnes (Companion), Mr. V. J. Chalwin (Associate), Mr. J. E. Chorlton (Companion), Mr. C. R. Elgie (Associate), Professor F. T. Hill (Fellow), Mr. G. Ingram (Companion), Sir Francis McClean (Associate Fellow), Mr. Peter Masefield (Associate Fellow), Mr. L. Mawer (Associate Fellow), Mr. J. P. Pryer (Associate Fellow), Mr. W. Reichsfeld (Associate Fellow), Warrant Officer J. V. Saunders (Associate Fellow), Lieut.-Col. S. Heckstall-Smith (Fellow), Mr. H. Smith (Student), Mr. R. T. Wall (Student), Dr. H. C. Watts (Fellow), Mr. J. A. C. Williams (Graduate), Mr. Lawrence A. Wingfield (Associate), Mr. R. T. Youngman (Fellow), Mr. A. R. Pitt (Student).

1. The Secretary read the Notice convening the Meeting as follows:—

NOTICE IS HEREBY GIVEN that a Special General Meeting, under Rule 100, of the Royal Aeronautical Society with which is incorporated the Institution of Aeronautical Engineers, will be held on Saturday, March 28th, 1942, at 3.30 p.m., in the Offices of the Society at No. 4, Hamilton Place, London, W.1, to consider the following alterations to the Rules:—

Rules numbered 3-8c inclusive to be re-numbered and to read as follows:—

RULE 3.—Fellows shall comprise every person who was on the Register on March 28th, 1942, as a Fellow of the Royal Aeronautical Society, with which is incorporated the Institution of Aeronautical Engineers, and every person thereafter elected or transferred into the class of Fellow.

RULE 4.—Election to Fellowship will be made annually by the Council for announcement at the Annual General Meeting of the Society in March.

RULE 5.—Nomination for Fellowship must be received by March 1st each year at the latest, for consideration at the March Council Meeting.

A Fellow must possess the following qualifications:—

RULE 6.—He shall be twenty-eight years of age or over.

RULE 7.—He shall be an Associate Fellow or shall have fulfilled the conditions necessary for Associate Fellowship.

RULE 8.—He shall have acquired a considerable degree of eminence in the profession of aeronautics.

RULE 11.—Delete the words " or serving as a pilot, engineer, or navigator of aircraft."

RULE 12.—After the second sentence to read:—" The Council may exempt a candidate therefrom to the extent to which he has passed equivalent examinations; or he may be totally exempted when he complies with the conditions of Rule 17."

RULE 14 (*b*).—Delete the words " or five years practical flying as experimental pilot."

RULE 15 (*b*).—Delete the words " or five years practical flying as experimental pilot."

RULE 17.—Alter the words " and have a record of distinguished service " to " and have a record of meritorious service."

RULE 28 (*b*).—Delete the words " or serving as a pilot, engineer, or navigator of aircraft."

RULE 29 (*d*).—Delete.

RULE 29 (*e*) and (*f*).—Renumber Rules 29 (*d*) and 29 (*e*) respectively.

A short discussion followed on the proposed alterations to the Rules, following which Mr. R. T. Youngman (Fellow) proposed and Mr. C. R. Elgie (Associate) seconded that the alterations should be accepted. The motion was carried unanimously.

PRESIDENT.

Mr. A. Gouge, B.Sc., F.R.Ae.S., was elected President of the Society for the year October, 1942—September, 1943.

VICE-PRESIDENTS.

The following were elected Vice-Presidents of the Society for the year October, 1942—September, 1943:—

Mr. E. F. Relf, F.R.S., F.R.Ae.S.
Dr. H. Roxbee Cox, D.I.C., B.Sc., F.R.Ae.S.

MEDALS AND AWARDS.

No awards have been made for the year, with the exception of the Elliott Memorial Prize and the Major Baden-Powell Memorial Prize awarded as follows:—

Elliott Memorial Prize ...	...	Aircraft Apprentice F. C. Bluott.
		Aircraft Apprentice H. H. J. Pidgeon.
Baden-Powell Memorial Prize ...		R. F. Creasey.
		H. Wilson.

HONOURS.

The following Members were recipients of Honours during the year:—

Baron.—Lieut.-Col. the Rt. Hon. J. T. C. Moore-Brabazon, M.C., Fellow.

Knights.—Mr. C. R. Fairey, M.B.E., Fellow; Mr. F. Handley Page, C.B.E., Fellow; Mr. R. A. Watson Watt, C.B., F.Inst.P., M.Inst.E.E., Fellow.

C.B.—Mr. W. P. Hildred, O.B.E., M.A. (Companion Member).

C.B.E.—Group Captain W. Helmore, Ph.D., M.Sc., Fellow.

D.S.O.—Wing Commander D. C. T. Bennett, Fellow.

SOCIETY OF BRITISH AIRCRAFT CONSTRUCTORS SCHOLARSHIPS.

The Scholarships Selection Committee of the Society of British Aircraft Constructors and the Royal Aeronautical Society made awards of S.B.A.C. Scholarships to the following:—

E. L. Goldsmith. S. D. Meston.
J. G. W. McHarry. D. R. Murrin.

WILBUR WRIGHT MEMORIAL LECTURE.

The 30th Wilbur Wright Memorial Lecture was delivered on May 28th, 1942, by the Rt. Hon. Lord Brabazon of Tara, M.C., P.C., F.R.Ae.S., entitled "Ad Astra." A full report was published in the Journal of the Society for October, 1942.

BRANCHES.

There are seventeen branches of the Society, some of which, despite the difficulties of the war situation, have proved very active and have held a considerable number of lectures. Many, however, have had to keep going with only a skeleton organisation so that they will be ready to function at the cessation of hostilities.

GRADUATES' AND STUDENTS' SECTION.

Chairman: Mr. J. A. C. Williams.
Vice-Chairman: H. Udall.
Secretary: R. T. Wall.
Committee: A. L. Benns, A. M. Edwards, F. V. K. Sutton, E. J. Archbold, J. P. Smith (ex-officio).

The following is a summary of the activities of the section during the past year:—

1. Annual General Meeting, 29th April, 1942.
2. 27th May, 1942.—Lecture on "Experimental Vibration Work on Aircraft," by Mr. R. N. Hadwin.
3. 17th June, 1942.—Lecture on "Fighter Aircraft Design," by Mr. F. H. M. Lloyd.
4. 15th July, 1942.—A talk by Mr. Frank W. Lane, entitled "Speed or Adventures with a Stop Watch," which illustrated high speed photography.
5. 12th August, 1942.—Informal discussion on "The War in the Air." Chairman and introducer, Mr. P. G. Masefield.
6. 2nd September, 1942.—Lecture on "Work in an Experimental Seaplane Tank," by Mr. L. Smith. Chairman, Dr. J. P. Gott, A.F.R.Ae.S.
7. 15th January, 1943.—Informal Supper Party at Schmidt's Restaurant. Mr. P. G. Masefield was the guest of the evening.

The average attendance at lectures and discussions was 41.

All the meetings were held in the Library of the Society.

It was not possible to arrange any visits to works as M.A.P. could not provide the facilities.

R. T. WALL, *Hon. Sec., Graduates' and Students' Section.*
J. A. C. WILLIAMS, *Chairman.*

ASSOCIATE FELLOWSHIP EXAMINATIONS.

The results of the Associate Fellowship Examinations held in May and December, 1942, were published in the Journal for July, 1942, and February, 1943. Despite the difficulties of training the Council note with satisfaction that there is a steady increase in the number of those taking the examinations over the pre-war period.

Notice was given early in the year that the new syllabus due to come into force in May, 1943, would be postponed until six months after the cessation of hostilities.

MEMBERS ELECTED DURING 1942.

The names of members elected in the various grades of the Society during 1942 have been published regularly in the Monthly Notices, now printed as part of the Journal.

ACKNOWLEDGMENTS.

The Council gratefully acknowledge the gifts of books, photographs, Journals and historical papers from members during the year. All gifts have been acknowledged, as received, in the Monthly Notices.

FINANCE.

The Income and Expenditure Accounts and Balance Sheets of Aerial Science Limited, and Aeronautical Trusts Limited, for 1942, are published in this issue of the Journal.

The Income and Expenditure Account of Aerial Science Limited, shows an excess of income over expenditure for the year of £1,050 18s. 7d., as against £1,001 0s. 3d. for 1941.

JOURNAL.

The Journal of the Society continues to maintain its standard in face of increasing difficulties of printing and paper shortage. During the year the Council announced a reduction in subscriptions to those members who were prepared to give up their Journal for the war period, so that paper could be conserved. The response has been most gratifying and generous. Over 500 members have signified their willingness to forego the Journal, and the Council wish particularly to place on record their thanks for the practical help members are giving in this way to keep up the standard of the Journal. Arrangements have been made to post all members who do not receive the Journal copies of the Monthly Notices.

The Journal has continued to publish during the year the Abstracts from the Scientific and Technical Press and References to Papers, as these are particularly valuable in enabling members to be kept informed of the contents of papers which normally they are unable to obtain.

The Income and Expenditure Account of Aerial Science, Limited, gives a summary of the expenditure on the Journal and sundry publications. The Income and Expenditure Account of the Journal is as follows (the figures in brackets are the corresponding figures for 1941).

(*Continued on page* 158.)

THE ROYAL

(Aerial

Balance Sheet,

	£ s. d.	£ s. d.
Share Capital —		
Authorised—		
20 Shares of 1/- each	1 0 0	
999 Shares of £1 each	999 0 0	
	1000 0 0	
Issued – 19 Shares of 1/- each, fully paid...		19 0
Sundry Creditors		1233 17 1
Subscriptions and Other Amounts Received in Advance		543 19 6
Staff Pension Fund		2245 9 0
Income and Expenditure Account—		
Balance at 31st December, 1941	3929 16 9	
Less—Additional amount transferred to Staff Pension Fund in respect of the years 1939, 1940 and 1941	1200 0 0	
	2729 16 9	
Add – Surplus of Income over Expenditure for year to date ...	1050 18 7	3780 15 4
		£7804 19 11

We report to the Members that we have examined the above Balance Sheet with the Books are of the opinion that the Balance Sheet is properly drawn up so as to exhibit a true and correct information and the explanations given to us and as shown by the Books of the Society.

3, Frederick's Place, Old Jewry, London, E.C.2.
24th February, 1943.

Income and Expenditure Account

	£ s. d.	£ s. d.	£ s. d. 1941 Figures.
To Establishment Expenses —			
Ground Rent, Heating, Lighting and Insurance		1531 17 10	(1601 13 5)
,, Office and Staff Expenses —			
Salaries	2463 13 9		(2332 0 8)
Printing and Stationery	565 2 9		(393 2 11)
Postages and Telephone	340 10 3		(357 16 6)
Other Charges	966 12 9	4335 19 6	(931 7 5)
			(4014 7 6)
,, Meetings		162 6 11	(48 4 7)
,, Library Expenses		74 11 6	(94 13 0)
,, Prizes and Donations		5 5 0	(5 5 0)
,, Legal and Professional Charges		132 13 7	(52 10 0)
,, Staff Pension Fund		500 0 0	(100 0 0)
,, Balance, being Surplus of Income over Expenditure for year carried to Balance Sheet		1050 18 7	(1001 0 3)
		£7793 12 11	

W. C. DEVEREUX, Chairman, Finance Committee.
A. N. D. SMITH, Honorary Accountant.

AERONAUTICAL SOCIETY

Science Limited)

31st December, 1942.

	£ s. d.	£ s. d.
Printed Books, Bindings, Old Prints, etc., at cost, less amounts written off		50 0 0
Stock of JOURNALS *and other Publications*		1 0 0
Investment in and amount due from Subsidiary Company Aeronautical Trusts Limited—		
21 Shares of 1/- each, fully paid, at cost	1 1 0	
Amount due on Current Account	1985 11 7	1986 12 7
Staff Pension Fund—		
Investment, at cost —		
£2335 10s. 7d. 2½ % Funding Loan, 1956/61	2201 4 2	
Cash at Bank	44 4 10	2245 9 0
Sundry Debtors	... ...	2087 6 9
Rent paid in advance	... ..	106 5 0
Cash at Bank and in Hand	... ...	1328 6 7
		£7804 19 11

of the Society, and have obtained all the information and explanations we have required. We view of the state of the Society's affairs as at 31st December, 1942, according to the best of our

(Signed) PRICE, WATERHOUSE & CO.

for the Year ending 31st December, 1942.

			£ s. d.	£ s. d.	£ s. d. 1941 Figures
By Annual Subscriptions			... ...	6149 9 9	(5604 16 0)
„ Donations			... ...	500 0 0	(500 0 0)
„ Receipts from JOURNAL and Sundry Publications—					
Sales			1590 14 5		(1460 3 0)
Advertisement Revenue			3230 15 5		(3344 18 3)
			4821 9 10		(4805 1 3)
Less Expenditure—					
Printing Costs	3234 4 9				(3356 12 3)
Postages	320 12 4				(401 0 5)
Other Charges	252 9 10		3807 6 11	1014 2 11	(168 19 0)
					(£3926 11 8)
„ Examinations—					
Fees Received	348 7 0				(108 10 0)
Less Expenses	218 6 9			130 0 3	(174 1 10
					(65 11 10) Loss)
				£7793 12 11	

Balance Sheet,

	£ s. d.	£ s. d.	£ s. d.
Share Capital—			
Authorised—40 Shares of 1/- each		2 0 0	
Issued—21 Shares of 1/- each fully paid			1 1 0
Royal Aeronautical Society Endowment Fund—			
Capital Account—Balance at 31st December, 1941 ...		77880 12 10	
Add Donations received during year		12979 9 11	
Entrance Fees received during year		483 0 0	
		91343 2 9	
Income Account—Balance at 31st December, 1941 ...	736 1 6		
Add—Surplus of Income over Expenditure for year to date	1274 0 0	2010 1 6	93353 4 3
Pilcher Memorial Fund—			
Capital Account—As at 31st December, 1941		99 14 0	
Income Account—Balance at 31st December, 1941 ...	39 8 4		
Add Income for year to date	4 0 8	43 9 0	143 3 0
Usborne Memorial Fund—			
Capital Account—As at 31st December, 1941		109 2 5	
Income Account—Balance at 31st December, 1941 ...	56 5 0		
Add Income for year to date	3 19 0	60 4 0	169 6 5
Herbert Akroyd Stuart Fund—			
Capital Account—As at 31st December, 1941		688 19 0	
Income Account—Balance at 31st December, 1941 ...	300 13 5		
Add Income for year to date	31 8 0	332 1 5	1021 0 5
R.38 Memorial Fund—			
Capital Account—As at 31st December, 1941		978 3 10	
Income Account—Balance at 31st December, 1941 ...	519 9 5		
Add Income for year to date	47 3 10	566 13 3	1544 17 1
Edward Busk Memorial Fund—			
Capital Account—As at 31st December, 1941		449 6 1	
Income Account—Balance at 31st December, 1941 ...	121 9 11		
Add Income for year to date	19 14 0	141 3 11	590 10 0
Wilbur Wright Memorial Fund—			
Capital Account—As at 31st December, 1941		1420 7 9	
Income Account—Balance at 31st December, 1941 ...	143 16 5		
Add Surplus of Income over Expenditure for year to date	6 17 8	150 14 1	1571 1 10
Simms Gold Medal Fund—			
Capital Account—As at 31st December, 1941		324 15 9	
Less—*Income Account*—			
Deficiency at 31st December, 1941	15 2 10		
Less Income for year to date	9 0 0	6 2 10	318 12 11
Alston Memorial Fund—			
Capital Account—As at 31st December, 1941		245 6 0	
Income Account—Balance at 31st December, 1941 ...	7 17 3		
Add—Income for year to date	7 5 10	15 3 1	260 9 1
			£98973 6 0

We report to the Members of Aeronautical Trusts Limited, that we have examined the above explanations we have required. We are of opinion that the Balance is properly drawn up December, 1942, according to the best of our information and the explanation given to us and as

5, Frederick's Place, Old Jewry, London, E.C.2.
24th February, 1943.

TRUSTS LIMITED

31st December, 1942.

	£ s. d.	£ s. d.	£ s. d.
Cash in Hand			1 1 0
Royal Aeronautical Society Endowment Fund—			
Leasehold Property at Cost—Less amount written off			
4, 8, and 9, Hamilton Place	10185 0 0		
Furniture at cost, *less* depreciation	3526 17 6		
Investments at Cost –	£ s. d.		
£6474 11s. 7d. 3½ % Conversion Loan	6192 5 1		
£4500 3 % War Loan, 1955/59	4497 0 2		
£15103 15s. 3d. 3½ % War Loan	14000 0 0		
£10000 2½ % National War Bonds, 1945/47	10000 0 0		
£1000 3 % Defence Bonds	1000 0 0		
£18500 3 % Savings Bonds, 1955/65	18500 0 0		
£10000 3 % Savings Bonds, 1960/70	10000 0 0		
£629 16s. 4d. London County Council 2¾ % Stock, 1960/70	600 0 0		
£2367 12s. 7d. Manchester 3 % Redeemable Stock, 1952/55	2388 12 11		
£4100 L.N.E. Rly. 3 % Debenture Stock	3162 6 3		
£3100 L.M.S. Rly. 4 % Debenture Stock	3162 19 9	73503 4 2	
Cash at Bank		2357 17 5	
Amounts due for refund of Income Tax, etc. ...		5765 16 9	
		95338 15 10	
Less –Amount due to Aerial Science Limited		1985 11 7	93353 4 3
Pilcher Memorial Fund—			
£115 6s. 10d. 3½ % War Loan at cost		116 5 0	
Cash at Bank		26 18 0	143 3
Usborne Memorial Fund—			
£113 3½ % War Loan at cost		114 11 1	
Cash at Bank		54 15 4	169 6 5
Herbert Akroyd Stuart Fund—			
£683 1s. 0d. 3½ % War Loan at cost		698 19 0	
£250 3 % Defence Bonds at cost		250 0 0	
		948 19 0	
Cash at Bank		72 1 5	1021 0 5
R.38 Memorial Fund—			
£1048 11s. 2d. 3½ % War Loan at cost		1098 18 10	
£350 3 % Defence Bonds at cost		350 0 0	
		1448 18 10	
Cash at Bank		95 18 3	1544 17 1
Edward Busk Memorial Fund—			
£284 4s. 2d. 3½ % War Loan at cost		284 4 2	
£217 London Transport 4½ % "A" Stock, at cost		199 4 6	
		483 8 8	
Cash at Bank		107 1 4	590 10 0
Wilbur Wright Memorial Fund—			
£1246 18s. 1d. 3½ % Conversion Stock, at cost		1000 0 0	
£530 2½ % National War Bonds, 1945/47, at cost		530 0 0	
		1530 0 0	
Cash at Bank		41 1 10	1571 1 10
Simms Gold Medal Fund—			
£300 3% Defence Bonds, at cost		300 0 0	
Cash at Bank		18 12 11	318 12 11
Alston Memorial Fund—			
£252 14s. 10d. 3 % War Loan 1955/59 at cost		250 0 0	
Cash at Bank		10 9 1	260 9 1
			£98973 6 0

Balance Sheet with the books of the Company and have obtained all the information and so as to exhibit a true and correct view of the state of the Company's affairs as at 31st shown by the books of the Company.

(Signed) PRICE, WATERHOUSE & CO.

AERONAUTICAL

INCOME & EXPENDITURE ACCOUNTS

Royal Aeronautical Society

	£	s.	d.
To Legal Charges	4	4	0
,, Amortisation of Leasehold Property	485	0	0
,, Depreciation of Furniture	213	15	0
,, Surplus of Income over Expenditure for year carried to Balance Sheet	1274	0	0
	£1976	19	0

Pilcher

To Income for year carried to Balance Sheet	4	0	8
	£4	0	8

Usborne

To Income for year carried to Balance Sheet	3	19	0
	£3	19	0

Herbert Akroyd

To Income for year carried to Balance Sheet	31	8	0
	£31	8	0

R.38

To Income for year carried to Balance Sheet	47	3	10
	£47	3	10

Edward Busk

To Income for year carried to Balance Sheet	19	14	0
	£19	14	0

Wilbur Wright

To 1942 Award	50	0	0
,, Surplus of Income over Expenditure for year carried to Balance Sheet	6	17	8
	£56	17	8

Simms Gold

To Income for year carried to Balance Sheet	9	0	0
	£9	0	0

Alston

To Income for year carried to Balance Sheet	7	5	10
	£7	5	10

TRUSTS LIMITED

FOR THE YEAR ENDED 31st DECEMBER, 1942.

Endowment Fund.

	£ s. d.
By Interest on Investments (gross)	934 4 11
,, ,, ,, ,, (*less* tax)	504 15 5
,, Refund of Income Tax	537 18 8
	£1976 19 0

Memorial Fund.

By Interest on Investments (gross)	4 0 8
	£4 0 8

Memorial Fund.

By Interest on Investments (gross)	3 19 0
	£3 19 0

Stuart Fund.

By Interest on Investments (gross)	31 8 0
	£31 8 0

Memorial Fund.

By Interest on Investments (gross)	47 3 10
	£47 3 10

Memorial Fund.

By Interest on Investments (gross)	9 18 10
,, ,, ,, ,, (*less* Tax)	4 17 8
,, Refund of Income Tax	4 17 6
	£19 14 0

Memorial Fund.

By Interest on Investments (gross)	56 17 8
	£56 17 8

Medal Fund.

By Interest on Investments (gross)	9 0 0
	£9 0 0

Memorial Fund

By Interest on Investments (less Tax)	3 15 10
,, Refund of Income Tax	3 10 0
	£7 5 10

OBITUARIES.

The Council record with deep regret the deaths of the following members since the publication of the last Council Report:—

*S./Ldr. Glyn Ashfield, D.F.C., A.F.C., Associate Fellow.
Mr. E. M. Boote, Companion.
*Capt. C. G. K. Browne, B.A., Associate.
*F./Lt. W. D. Castello, D.F.C., Associate.
*Flight Sgt. S. A. Conibear, Student.
*Mr. E. D. Crisp, Associate.
Mr. E. J. Crow, Associate.
*Mr. C. H. Danielson, Student.
*Capt. G. P. M. Eves, Associate.
Dr. Ing. L. Frommer, Associate Fellow.
*W./Cmdr. R. O. M. Graham, D.F.C., Associate.
*P./O. J. C. Hardman, Graduate.
*Capt. T. R. Harms, Associate Fellow.
*S./Ldr. L. A. G. Howard, B.A., Associate Fellow.
*Mr. C. C. Login, Companion.
*S./Ldr. W. M. Protheroe, F.R.Met.S., Associate.
*Mr. Peter Richardson, Student.
*Mr. R. H. Shaw, Student.
*F./Lt. C. S. Staniland, Associate.
*Mr. E. R. Staniland, B.Sc., Associate Fellow.
*Sgt. Pilot E. Swingler, Student.

*Killed on War Service or by enemy action.

REVIEWS.

Britain and World Air Transport.

By B. J. Hurren. John Crowther, Ltd. 1943. 2/6.

It is a pity that this interesting and provocative essay should be presented in the form of a 56-page pamphlet, for the (admittedly illogical) tendency of readers is to judge the importance of a writer's views according to the style in which they are produced; " paper-back " literature, unless issued under the ægis of a research society, is seldom taken seriously. Lieut.-Com. Hurren's views are, however, worth serious consideration. He obviously has the necessary technical experience to write on Civil Aviation, joined to a refreshing degree of commonsense and a style that is full of " punch." After telling us in no uncertain terms what you can *not* do in the air (" . . . the monster aeroplane so glibly discussed by enthusiasts has the natural limitation, at present, that it would have no aerodrome to depart from and none capable of accepting it from flight without accident " . . .) and what he considers could and should be done . . . in general, to provide for the passenger's comfort, under the most varying climatic conditions, in the air, and his adequate housing on the ground . . . the author gives a brief survey of the political problems that will confront Civil Aviation in the post-war world. In conclusion, he states his own radical views on the education in air-mindedness of the new generation and the planning of a world in which aviation plays an intrinsic part. Put briefly, his proposals are:—(1) To build cities around airports, rather than add airports to existing cities; (2) to send aircraft designers on world-trips by air, so that they shall have practical experience of the conditions their machines will have to meet; (3) to give free holiday air passages to all wartime factory workers; (4) to abolish the teaching of geography—" loathed and detested by every healthy schoolboy "—and substitute lessons on aviation in the form of world air transport; (5) to institute Degrees in Aviation at the Universities; (6) as a major issue, to divorce British civil aviation from military control. This programme is certainly sweeping, but it is argued with a cogency and coherency that remove it from the sphere of mere Utopianism.

Combat Report. (The Story of a Fighter Pilot.)

By Hector Bolitho. B. T. Batsford, Ltd. 1943. 8/6.

Narratives written by or about fighter pilots fall into two classes: Those of the pilot himself, who usually flies better than he writes, and those of a journalist, incidentally attached to the Air Force, who knows how to present his subject but sees it from the outside. Mr. Bolitho, whose acquaintance with flying and pilots goes back to pre-war days, has achieved a happy combination of both methods; the story of his fighter pilot friend, whom he calls " John," is presented mainly through the medium of John's own letters, but they are linked up and interpreted by the comments of a skilled writer. The result is one of the best books we have read about war flying, since Paul Richey's " Fighter Pilot." We particularly liked Mr. Bolitho's description of " Batchy " Atcherley: " Tall and lean and so energetic that he always seemed to be walking one pace ahead of himself "; of a flight over the Dead Sea: " So low over the ancient water that the blossoms on the oleander bushes met me at eye level "; his analysis of the way in which the British pilots evolved from their first sporting fellow-feeling for their opponents to the point where: " The mature pilots of the Service are out to kill, without any songs upon their lips or muddling of conscience "; and

his illuminating sentence: "The gaiety of pilots has always been that of men who were prepared to die at any moment, in return for the privilege of enjoying the beauty and danger of flight." These are things that the pilots themselves know, but very rarely have the power to express. The publishers are to be congratulated upon the presentation of this book, which shows that even in wartime it is possible to provide the good quality paper and well-spaced type that make for pleasant reading.

WINGS ON HER SHOULDERS.

By Katharine B. Beauman. Hutchinson and Co. 1943. 8/6.

With the exception of an official Air Ministry pamphlet intended for prospective recruits to the W.A.A.F., nothing has so far been written about this most important branch of women's war work. Flight Officer Beauman is in a good position to fill this gap, as she joined the W.A.A.F. in the spring of 1939 and watched it expand from a small group of enthusiasts, at best tolerated and more often actively or passively discouraged by the authorities, to its present status as an integral part of the Royal Air Force. The authoress writes with sympathy and humour, describing the early, experimental days, the discomforts caused by shortages of equipment and deficiencies in accommodation, the courage shown by the airwomen when they first came under fire during the Battle of Britain, the gradual evolution of system and efficiency, and the many branches of technical training that are now open to members of the W.A.A.F. It is a gallant story, told from the inside, which will be read with equal enjoyment by men and women alike, and its moral is summed up in a neat definition of discipline as: "The cheerful obedience to orders recognised as reasonable"—a spirit which should certainly go far towards winning the war.

ASTRONOMICAL AIR NAVIGATION.

By Sq. Ldr. R. Hadingham. The Technical Press, Ltd. 1943. 10/6.

It is a pity that this book starts with the grammatical blunder of reproducing a plate of Tycho Brahe with the caption "*Tychonis* Brahe" (due to rendering the inscription: "Effigies Tychonis Brahe . . .," etc., as it stands), for the author is obviously a better navigator than Latinist. His aim, as stated in the Preface, is "to provide a complete course in Astro-Navigation, with only essential references to the mathematical and theoretical aspect." Whether it is possible to do this without giving the student a thorough grasp of plane and spherical trigonometry, is a moot point, but "short-cut" methods have to be universally adopted in wartime. The first 40 pages deal with definitions and procedure and contain a satisfactory number of diagrams and worked examples. This is followed by a chapter on Star Identification, in which the main types of Planisphere are illustrated and explained. The notes on "Practical Work in the Air" are full of useful hints to both pilot and navigator, written from a common-sense angle that reveals long experience. These are followed by some elementary remarks on Precession, the Astronomical Triangle, and general Astronomy, which will be useful to the student as a basis for the study of more advanced books, while the concluding chapters describe the construction and use of the Mk. IX Sextant and the use of Star Curves.

THE FLYING GUNS.

By Lieut. Clarence E. Dickinson, U.S.N. Chas. Scribner's Sons. 1943. 10/6.

Here is a book that can be unreservedly recommended to "boys of all ages from nine to ninety"; even a hardened reviewer can swallow it at a sitting and then go round saying to all and sundry: "You *must* read this!" It starts on the historic morning of December 7, 1941; the author is flying back to Pearl

Harbour from an aircraft carrier when he sees a column of smoke ahead, which he supposes to come from the customary harvest burning of sugar-cane leaves, and a " ragged pattern of silvery splashes " in the water, which he at first interprets as target-practice. Hardly has it dawned upon him that this is, in fact, war, when he is set upon by a Zero fighter: " The red disk on the white wing reminding me of a big fried egg with a red yolk." In less than three pages of breathless narrative he has accounted for the Jap, has had his rear gunner killed and has himself been shot down, has parachuted to the ground and begged a lift from a passing motorist on a picnic expedition. Again and again we have to remind ourselves that this is not a schoolboy thriller, but actual fact; that at the moment when the Japanese attacked, ordinary citizens were still going about their work and play with an idea that the unwonted noise was part of some large-scale manœuvres. There follows a vivid description of Lieut. Dickinson's return, in the midst of dive-bombing and machine-gunning, to his base aerodrome, his flight through American anti-aircraft fire back to the carrier, and sinking of a submarine. The book continues in the same breathless strain, up to its climax in the famous battle of Midway Island. It is written in a terse idiom that goes well with the subject, and shows more power of description and characterisation than is usual in similar narratives by English pilots.

CORRESPONDENCE.

The National Physical Laboratory,
Teddington, Middlesex,
Engineering Department,
6th April, 1943.

To the Editor of the JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY.

Dear Sir,—Referring to Mr. R. G. Manley's paper on the electro-mechanical analogy, he and Mr. Fairthorne succeed between them in creating considerable confusion as to the system in which capacity is identified with mass. As Mr. Fairthorne states, this system is in some ways preferable to that described by Mr. Manley; but of course the identity of force with e.m.f. no longer holds.

The system to which Mr. Fairthorne refers has the following equivalents:—

Force = current.
Velocity = potential difference.
Mass = capacity.
Stiffness = reciprocal of inductance (susceptance).
Damping factor = reciprocal of resistance (conductance).

As the electrical use of conductance and susceptance suggests, this system is more convenient for circuits in parallel than for circuits in series, and the analogies in this system avoid the inversions from series to parallel circuits, which Mr. Manley's system involves. Nevertheless the conversion from electrical to mechanical circuit is not quite so straightforward as Mr. Fairthorne implies. The velocity of a mass has to be referred to some reference point and this point represents the second " terminal " of the mass represented as a capacity. As a result capacities in series have to be represented as masses joined by levers actuated at intermediate points on the levers. Conversion from mechanical to electrical circuit may seldom introduce this kind of complexity; but it is too much to claim that the mechanical and electrical circuits are identical.

To identify force with current and velocity with p.d. may at first sight appear unnatural and awkward; but, if attention be confined to the magnetic aspect of the electrical circuit, the analogy is fully consistent. In this view, displacement is analogous to flux linking a (single turn) coil; velocity, that is rate of change

of displacement is analogous to rate of change of linkage, that is e.m.f.; whilst force compares with the force on a conductor carrying an electric current in a magnetic field. In fact by the introduction of a D.C. field, mechanical velocity is directly convertible into e.m.f. and electric current into mechanical force.

This brings us to our chief reason for contributing to this correspondence, to rebut Mr. Fairthorne's dismissal of the analogy as virtually useless. Recently in the design of an electrical drive for a mechanical oscillatory system, we were in effect compelled to represent the mechanical system by its electrical analogue in the force-current system; in fact, had the quantities in the electrical analogue not been inconveniently large, we should have proceeded to build up the mechanical system as an equivalent electrical network, in order to try out certain control gear by which amplitude of mechanical vibration was to be controlled.

Finally it is worth while remarking that the electrical analogies are virtually limited to systems possessing one degree of freedom only. To represent systems having more than one degree of freedom. it is, in general, necessary to introduce transformers and, since these must be perfect, the analogies can seldom be of practical use. On the other hand, the statement by Dr. Firestone, in J. App. Phys., 9 pp., 373-387 (the reference is wrongly printed in Mr. Fairthorne's letter) that the analogy cannot be applied to transients is quite unjustified. Properly drawn the electrical analogy represents the mechanical system exactly under all conditions.

Yours faithfully,

F. Aughtie.

H. L. Cox.

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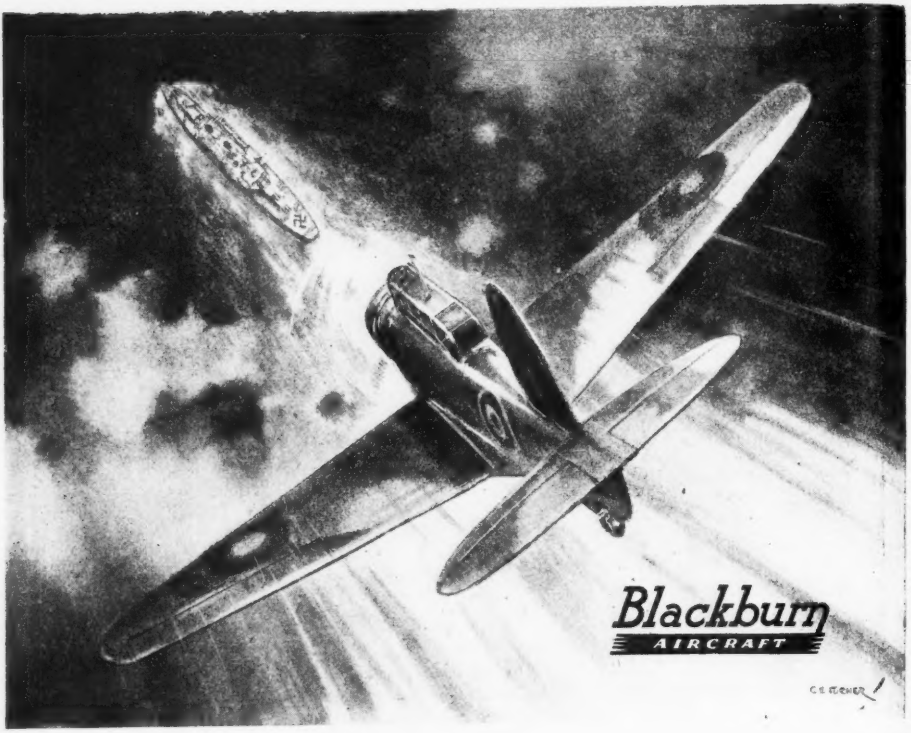

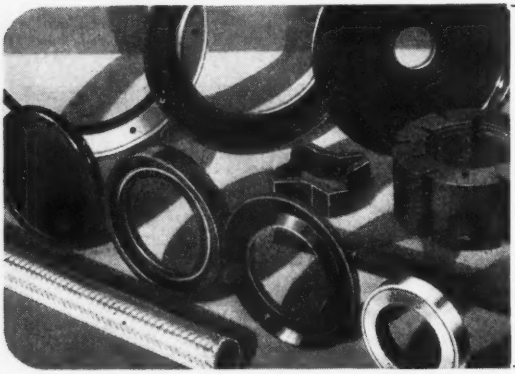

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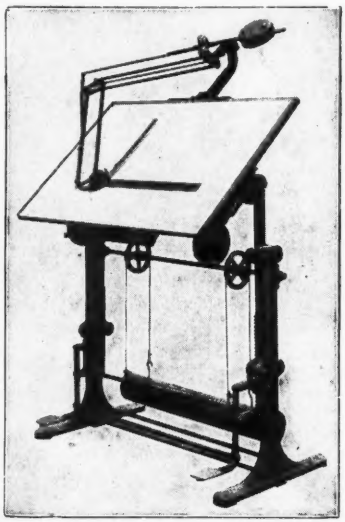

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